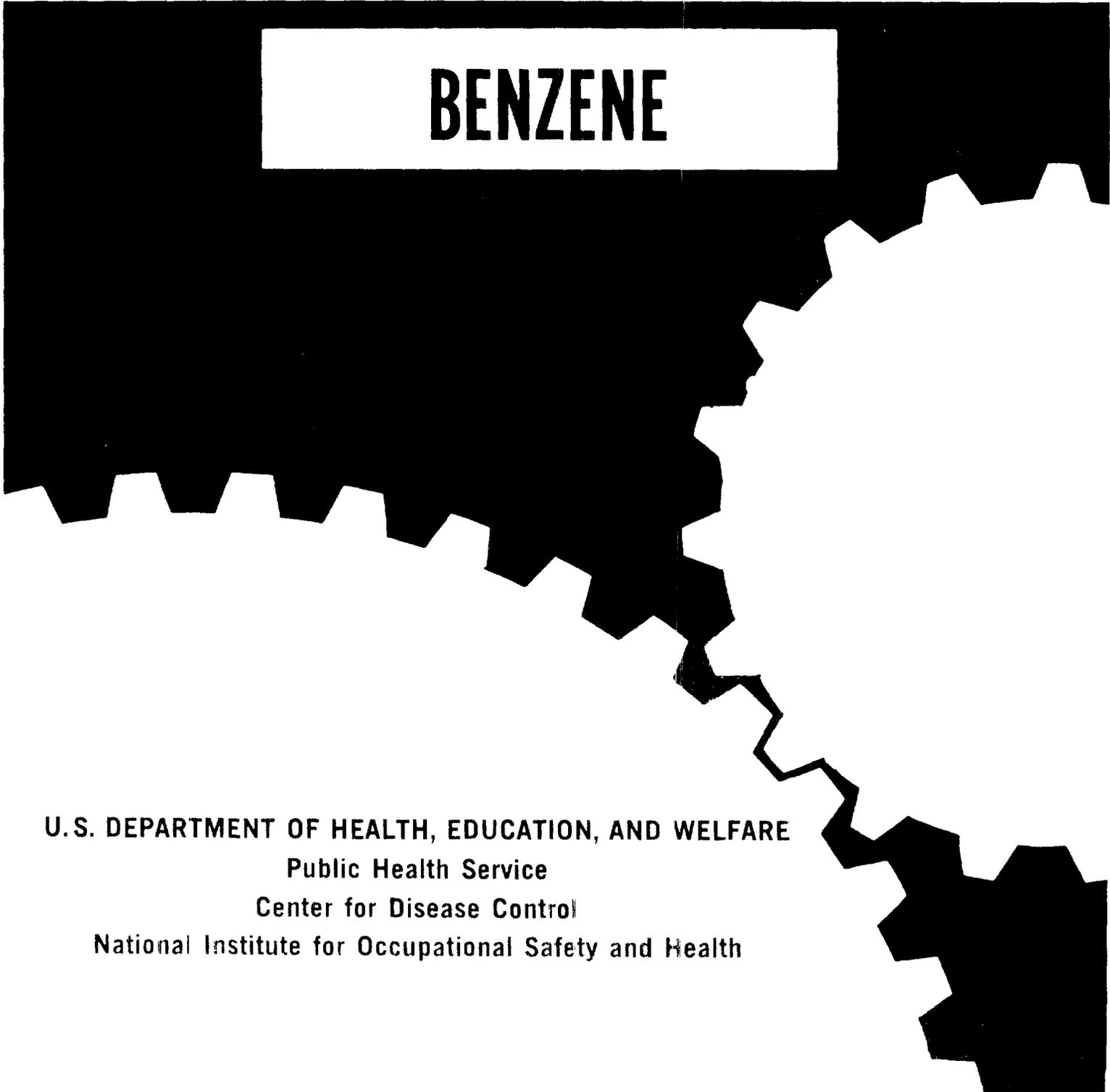


criteria for a recommended standard

OCCUPATIONAL EXPOSURE TO



BENZENE

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

criteria for a recommended standard

**OCCUPATIONAL EXPOSURE
TO
BENZENE**



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

Center for Disease Control

National Institute for Occupational Safety and Health

1974

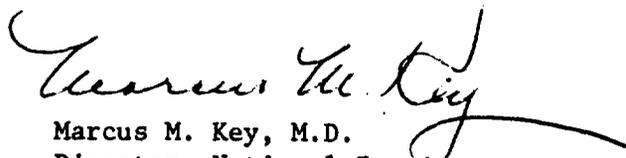
HEW Publication No. (NIOSH) 74-137

PREFACE

The Occupational Safety and Health Act of 1970 emphasizes the need for standards to protect the health and safety of workers exposed to an ever-increasing number of potential hazards at their workplace. To provide relevant data from which valid criteria and effective standards can be deduced, the National Institute for Occupational Safety and Health has projected a formal system of research, with priorities determined on the basis of specified indices.

It is intended to present successive reports as research and epidemiologic studies are completed and sampling and analytical methods are developed. Criteria and standards will be reviewed periodically to ensure continuing protection of the worker.

I am pleased to acknowledge the contributions to this report on benzene by members of my staff, the valuable and constructive comments presented by the review consultants on benzene, the ad hoc committees of the American Academy of Occupational Medicine and the Society of Toxicology, by Robert B. O'Connor, M.D., NIOSH consultant in occupational medicine, and by Professor William A. Burgess, NIOSH consultant on respiratory protection. The NIOSH recommendations for standards are not necessarily a consensus of all the consultants and professional societies that reviewed this criteria document on benzene. Lists of the NIOSH Review Committee members and of the Review Consultants appear on the following pages.


Marcus M. Key, M.D.
Director, National Institute
for Occupational Safety and Health

The Office of Research and Standards Development, National Institute for Occupational Safety and Health, had primary responsibility for development of the criteria and recommended standard for benzene. George D. Clayton and Associates developed the basic information for consideration by NIOSH staff and consultants under contract No. HSM-99-72-26. Douglas L. Smith, Ph.D., served as criteria manager and had NIOSH program responsibility for development of the document.

NIOSH REVIEW CONSULTANTS ON
BENZENE

Louis S. Beliczky
Director of Industrial Hygiene
United Rubber, Cork, Linoleum and
Plastic Workers of America
Akron, Ohio 44308

Robert E. Eckardt, M.D., Ph.D.
Director, Medical Research Division
Esso Research and Engineering Company
Linden, New Jersey 07036

Carl A. Nau, M.D.
Director, Institute of Environmental Health
University of Oklahoma Medical Center
Oklahoma City, Oklahoma 73104

Leonard D. Pagnotto
Chief of Laboratory
Division of Occupational Hygiene
Massachusetts Department of Labor and Industries
Boston, Massachusetts 02116

Jeanne M. Stellman, Ph.D.
Presidential Assistant for Health and Safety
Oil, Chemical and Atomic Workers International Union
Denver, Colorado 80201

Richard D. Stewart, M.D.
Professor and Chairman, Department of Environmental Medicine
Allen-Bradley Medical Science Laboratory
Medical College of Wisconsin
Milwaukee, Wisconsin 53226

REVIEW COMMITTEE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

Paul E. Caplan
Deputy Director, Division of
Technical Services

William M. Johnson, M.D.
Deputy Director, Division of
Field Studies and Clinical Investigations

Marshall E. LaNier
Regional Program Director
Region V

Trent R. Lewis, Ph.D.
Division of Laboratories and
Criteria Development

Frank L. Mitchell, D.O.
Office of Research and
Standards Development

Ann T. Saalwaechter
Division of Laboratories and
Criteria Development

Ex Officio:

Charles H. Powell, Sc.D.
Assistant Institute Director
for Research and Standards Development

CRITERIA DOCUMENT: RECOMMENDATIONS FOR AN
OCCUPATIONAL EXPOSURE STANDARD FOR BENZENE

Table of Contents

	<u>Page</u>
PREFACE	
REVIEW COMMITTEES	
I. RECOMMENDATIONS FOR A BENZENE STANDARD	
Section 1 - Environmental (Workplace Air)	1
Section 2 - Medical	2
Section 3 - Labeling (Posting)	7
Section 4 - Personal Protective Equipment and Protective Clothing	7
Section 5 - Informing Employees of Hazards from Benzene	13
Section 6 - Work Practices	13
Section 7 - Monitoring and Reporting Requirements	15
II. INTRODUCTION	18
III. BIOLOGIC EFFECTS OF EXPOSURE	
Extent of Exposure	20
Historical Reports	22
Effects on Humans	23
Epidemiologic Studies	29
Animal Toxicity	46
Correlation of Exposure and Effect	53
IV. ENVIRONMENTAL DATA	
Environmental Concentrations	57
Environmental Sampling and Analytical Method	61
Sorbability of Benzene on Charcoal	62
Accuracy and Precision Data	64
V. DEVELOPMENT OF STANDARD	
Basis for Previous Standards	68
Basis for Recommended Environmental Standard	70
Basis for Biologic Monitoring	75
Basis for Biologic Sampling and Analytical Method	80

Table of Contents
(continued)

	<u>Page</u>
VI. REFERENCES	83
VII. APPENDIX I - Method for Sampling and Analytical Procedures for Determination of Benzene	93
VIII. APPENDIX II - Methods for Determination of Exposure Areas to Benzene	105
IX. APPENDIX III - Biologic Method for Sampling and Analysis of Benzene	109
X. APPENDIX IV - Special Medical Considerations	113
XI. APPENDIX V - Material Safety Data Sheet	116
XII. TABLES AND FIGURES	121

I. RECOMMENDATIONS FOR A BENZENE STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that worker exposure to benzene in the workplace be controlled by adherence to the following sections. The standard is designed to protect the health and safety of workers for up to a 40-hour workweek over a working lifetime; compliance with the standard should therefore prevent adverse effects of benzene on the health and safety of workers. The standard is measurable by techniques that are valid, reproducible, and available to industry and government agencies. Sufficient technology exists to permit compliance with the recommended standard. The standard will be subject to review and revision as necessary.

These criteria and recommended standard apply to occupational exposure of workers to the aromatic hydrocarbon C_6H_6 , hereinafter referred to as "benzene." Synonyms for benzene include benzol, benzole, coal naphtha, cyclohexatriene, phene, phenyl hydride, and pyrobenzol. Benzin, petroleum benzin, and benzine are terms used for a mixture of saturated aliphatic hydrocarbons and should not be confused with benzene.

Section 1 - Environmental (Workplace Air)

(a) Concentration

Occupational exposure to benzene shall be controlled so that workers shall not be exposed to benzene at a concentration greater than 10 parts per million parts of air (32 milligrams per cubic meter of air) determined as a time-weighted average (TWA) exposure for up to a 10-hour workday, 40-hour workweek with a ceiling of 25 parts per million parts of air (80

milligrams per cubic meter of air) as determined by a sampling time of 10 minutes.

(b) Sampling and Analysis

Procedures for sampling, calibration of equipment, and analysis of environmental samples shall be as provided in Appendix I or by any method shown to be equivalent in accuracy, precision, and sensitivity to the method specified.

(c) Exposure

"Exposure to benzene" means exposure to a concentration of benzene above one-half the recommended environmental standard. Exposures at lower environmental concentrations will not require adherence to the following sections except for Sections 4 (b)(c), Skin and Eye Protection, and 6(a)(d)(e) of Work Practices. Procedures for identification of exposure areas can be accomplished by time-weighted average (TWA) determinations by methods described in Appendices I and II or by any method shown to be equivalent in accuracy, precision, and sensitivity to the methods specified.

If "exposure" to other chemicals also occurs, for example to toluene, provisions of any applicable standards for the other chemicals shall also be followed.

Section 2 - Medical

Medical monitoring (biologic monitoring and medical examinations) shall be made available to workers as outlined below.

(a) Biologic Monitoring

Biologic monitoring shall be provided to all workers subject to "exposure to benzene." It consists of sampling and analysis of urine for total phenol content. Such monitoring shall be performed to ensure that no worker absorbs an unacceptable amount of benzene. Unacceptable absorption of benzene posing a risk of benzene poisoning is demonstrated at levels of 75 mg phenol/liter of urine (with urine specific gravity corrected to 1.024) or greater as sampled and determined by the method specified in Appendix III, or alternative methods shown to be equivalent in accuracy and precision. "Spot" urine specimens of about 100 ml shall be collected as close to the end of the working day as feasible. Any urine specimens with a specific gravity less than 1.010 shall be discarded and another sample obtained.

To satisfy the biologic monitoring requirement, every worker subject to "exposure to benzene" shall have urine sampling and analysis made available to him at quarterly intervals. The schedule of biologic monitoring may be altered if indicated by the results of a professional industrial hygiene survey. If environmental sampling and analysis demonstrate that environmental levels are at, or greater than, the environmental limit, the interval of biologic monitoring shall be increased so that a phenol analysis shall be conducted every 2 weeks on every worker. This increased frequency shall be continued for at least 2 months after the high environmental level has been demonstrated.

If a worker's urine phenol level is found to be 75 mg/liter or greater, calculated to a specific gravity of 1.024, two followup urine samples shall be obtained within 1 week after receipt of the results, one

as close to the beginning and one as close to the end of the same working day as possible. If the original elevated finding is confirmed, steps to reduce the worker's absorption of benzene shall be taken promptly. Steps to be considered should include improvement of environmental controls, of personal protection or personal hygiene, and the use of administrative controls. For those workers with confirmed high biologic levels of phenol as determined from the biologic sampling, a medical examination for possible benzene poisoning shall be considered and the OSHA area industrial hygienist shall be informed.

Biologic monitoring shall also be provided where the OSHA area industrial hygienist has reason to believe operations produce unusual exposure excursions or that environmental samples do not adequately describe worker exposure.

(b) Medical Examinations

Medical examinations shall be provided for all workers subject to "exposure to benzene" or when unacceptable absorption of benzene is demonstrated as judged by biologic monitoring. An evaluation of the advisability of a worker's using negative- or positive-pressure respirators shall also be made.

(1) Preplacement and Annual

Comprehensive preplacement and annual physical examinations, to include medical histories, shall be provided for all workers. Initial examinations for presently employed workers shall be offered within 6 months of the promulgation of a standard incorporating these recommendations and annually thereafter. The medical history should include information on previous exposures to benzene and any other

hematologic toxin; blood dyscrasias including, but not limited to, genetically related hemoglobin alterations, bleeding abnormalities, and abnormalities in the function of formed blood elements; renal disease; liver disease; alcoholic intake; and infection. Laboratory examinations at the time of the preplacement examination shall include, but shall not be limited to:

(A) Complete blood count, including hematocrit, hemoglobin, mean corpuscular volume, white blood cell count including a differential count, and platelet estimation from the differential slide.

(B) Reticulocyte count.

(C) Serum bilirubin.

(D) Urinary phenol.

(2) Quarterly

Each worker exposed to benzene shall have laboratory examinations provided at 3-month intervals as prescribed for the preplacement and annual examinations but not necessarily including the reticulocyte count and serum bilirubin requirements.

(3) Monthly

Monthly laboratory examinations, or more or less frequently as indicated by professional judgment, as prescribed for the quarterly requirements, shall be provided if, in the opinion of the responsible physician, a worker shows alterations in the formed elements of the blood as compared with previous results which are judged as sufficient to warrant more frequent observations. This schedule shall continue for at least 3 months thereafter until there is evidence of return to normal values (see Appendix IV) or other reasons indicate discontinuance.

(4) Two-Week Intervals

Each worker exposed to benzene in excess of a time-weighted average concentration which exceeds the standard shall have the laboratory examinations provided every 2 weeks as prescribed for the preplacement and annual examinations. If evidence of benzene poisoning is developed from these examinations, the worker should be kept under a physician's care until the worker has completely recovered or maximal improvement has occurred. Ordinarily, this is mandatory in most workmen's compensation jurisdictions.

Each employee who absorbs unacceptable amounts of benzene as indicated by biologic monitoring shall be examined as soon as practicable after such absorption is demonstrated and confirmed, and at least monthly thereafter, until his urine phenol levels have returned to normal, ie, below 75 mg/liter of urine.

Medical records shall be maintained for persons employed in work involving exposure to benzene and shall include information on all biologic determinations and on all required medical examinations. Medical records with pertinent supporting documents shall be maintained at least 20 years after the individual's employment is terminated. These records shall be available to the medical representatives of the Secretary of Health, Education, and Welfare, of the Secretary of Labor, of the employee or former employee, and of the employer.

Section 3 - Labeling (Posting)

The following sign shall be affixed in a readily visible location at or near entrances to areas in which there is the likelihood of occupational exposure to benzene:

DANGER!

BENZENE

EXTREMELY FLAMMABLE:

Keep away from heat, sparks, and open flame.

VAPOR HARMFUL

High concentrations of vapor
are hazardous to health.
Provide adequate ventilation.

This warning sign shall be printed both in English and in the predominant language of non-English-speaking workers, unless they are otherwise trained and informed of the hazardous areas. All illiterate workers shall receive such training.

Section 4 - Personal Protective Equipment and Protective Clothing

Engineering controls shall be used to maintain benzene exposures below the prescribed limit. Administrative controls may also be used to reduce exposure. Requirements for personal protective equipment shall be as approved under provisions of 29 CFR 1910 (37 FR 22102, Subpart I, October 18, 1972, as amended).

(a) Respiratory Protection

This subsection shall apply whenever a variance from the standard recommended in Section 1(a) is granted under provisions of the Occupational

Safety and Health Act, or in the interim period during the application for a variance. When the limits of exposure to benzene prescribed in subsection (a) of Section 1 cannot be met by controlling the concentration of benzene in the work environment, an employer must utilize, as provided in this subsection, a program of respiratory protection to effect the required protection of every worker exposed. Respirators shall also be provided and used for nonroutine operations (occasional brief exposures above the ceiling of 25 ppm and for emergencies); however, for these instances, a variance is not required, but the requirements set forth below continue to apply. Appropriate respirators as described in Table I-1 shall only be used pursuant to the following requirements:

(1) For the purpose of determining the type of respirator to be used, the employer shall measure the atmospheric concentration of benzene in the workplace when the initial application for variance is made and thereafter whenever process, worksite, climate, or control changes occur which are likely to increase the benzene concentration. The employer shall ensure through proper respirator selection, fit, use, and maintenance that no worker is being exposed to benzene in excess of the standard.

(2) The respirator and cartridge or canister used shall be of the appropriate class, as determined on the basis of exposure to benzene.

(3) A respiratory protective program meeting the general requirements outlined in section 3.5 of American National Standard Practices for Respiratory Protection Z88.2-1969 shall be established and enforced by the employer. In addition, Sections 3.6 (Program

Administration), 3.7 (Medical Limitations), and 3.8 (Approval) shall be adopted and enforced.

(4) The employer shall provide respirators in accordance with Table I-1 and shall ensure that the employee uses the respirator provided.

(5) Respiratory protective devices described in Table I-1 shall be those approved under provisions of 30 CFR 11 (37 FR 6244, March 25, 1972) as amended.

(6) Respirators specified for use in higher concentrations of benzene are permitted in atmospheres of lower concentrations.

(7) Employees shall be given instruction on the use of respirators assigned to them, day-to-day maintenance and cleaning of the respirators, and how to test for leakage.

(8) Emergency and escape-type respirators shall be made immediately available at the work stations for each worker.

TABLE I-1

REQUIREMENTS FOR RESPIRATOR USAGE - BENZENE

<u>Maximum Use Concentration</u> <u>(Multiples of TWA limit)</u>	<u>Respirator Type</u> <u>for Benzene</u>
Less than or equal to 10x	<p>(1) Chemical cartridge respirator with organic vapor cartridge(s) and quarter or half mask.</p> <p>(2) Type C supplied air respirator, demand type (negative pressure), with quarter or half mask.</p>
Less than or equal to 100x	<p>(1) Gas mask with chin style canister for organic vapors.</p> <p>(2) Gas mask with front or back mounted chest type canister for organic vapors.</p> <p>(3) Type C supplied air respirator, demand (negative pressure), with full facepiece.</p> <p>(4) Self-contained breathing apparatus in demand mode (negative pressure) with full facepiece.</p> <p>(5) Combination supplied air respirator, pressure-demand type, with auxiliary self-contained air supply and full facepiece.</p>
Greater than 100x	<p>(1) Self-contained breathing apparatus in pressure-demand mode (positive pressure). with full facepiece.</p> <p>(2) Type C supplied air respirator, pressure-demand or continuous flow type with full facepiece or hood.</p> <p>(3) Combination supplied air respirator, pressure-demand type, with auxiliary self-contained air supply with full facepiece.</p>

TABLE I-1
(continued)

REQUIREMENTS FOR RESPIRATOR USAGE - BENZENE

<u>Maximum Use Concentration</u> <u>(Multiples of TWA limit)</u>	<u>Respirator Type</u> <u>for Benzene</u>
Emergency (No concentration limit)	(1) Self-contained breathing apparatus in pressure-demand mode (positive pressure) with full facepiece. (2) Combination supplied air respirator, pressure-demand type, with auxiliary self-contained air supply and full facepiece.
Evacuation or escape (No concentration limit)	(1) Self-contained breathing apparatus in demand or pressure-demand mode (negative or positive pressure). (2) Gas mask with organic vapor canister and mouthpiece respirator.

(b) Skin Protection

(1) Benzene-wetted clothing shall be removed promptly and benzene-exposed parts of the body shall be washed thoroughly.

(A) Workers wearing benzene-wetted clothing shall not be permitted to smoke or go near heaters or open flames.

(B) Benzene-wetted clothing shall not be placed in proximity of flames, heaters, or spark-producing equipment, and shall be free of vapor before being reworn.

(2) Workers shall be warned to avoid situations during extremely cold weather in which liquid benzene could freeze on clothing and vaporize on entering warm areas, thus posing a serious health or fire hazard to the wearer.

(3) Protective clothing, consisting of coveralls or similar full-body clothing should be worn and should be changed at least twice weekly.

(4) If operations require continued exposure to liquid benzene, workers shall wear impervious clothing, gloves, or coverings to protect potentially exposed areas of the body. Consideration shall be given to the heat stress factors involved when wearing impervious clothing.

(c) Eye Protection

Eye protective equipment shall be provided by the employer and used by the employee where eye contact with liquid benzene is likely to occur from spill, splash, or spray.

(1) Selection, use, and maintenance of eye protective equipment shall be in accordance with provisions of the American National Standard Practice for Occupational and Educational Eye and Face Protection, ANSI Z87.1-1968.

(2) Spectacle-type safety goggles-- metal or plastic rim safety spectacles with unperforated side shields, or suitable all-plastic safety goggles equipped with approved impact-resistant glass or plastic lenses shall be worn when there is danger of benzene contact with the eye. Prescription lenses shall be provided for those employees who need them.

(3) Face shields-- full length, 8-inch minimum plastic shields with forehead protection may be worn in place of, or in addition to, goggles. If there is danger of material striking the eyes from underneath, or around the sides of the face shield, safety goggles shall be worn as added protection.

Section 5 - Informing Employees of Hazards from Benzene

At the beginning of employment in a benzene area, employees exposed to benzene shall be informed of hazards, relevant symptoms of overexposure, appropriate emergency procedures, and proper conditions and precautions for safe use of benzene. The information shall be posted in the work area, and maintained on file, and be readily accessible to the worker at all places of employment where benzene is involved in unit processes and operations or is released as a product, byproduct, or contaminant.

A continuing educational program shall be instituted to ensure that all workers have current knowledge of job hazards, proper maintenance procedures and cleanup methods, and that they know how to correctly use respiratory protective equipment and protective clothing.

Information as required shall be recorded on US Department of Labor Form OSHA-20 "Material Safety Data Sheet" or a similar form approved by the Occupational Safety and Health Administration, US Department of Labor.

Section 6 - Work Practices

(a) Smoking

Smoking materials, including personal matches and lighters, shall be prohibited in all areas where there is benzene.

(b) Emergency Procedures

(1) Fire fighting procedures shall be established and implemented to meet foreseeable events; these shall include procedures for emergencies involving release of benzene vapor.

(2) Where there is the possibility of benzene contact on the eyes or skin, safety showers, eye-wash fountains, and cleansing

facilities shall be installed and maintained to provide prompt, immediate access by the workers.

(3) Appropriate respirators shall be immediately available for wear during emergency situations and evacuation or escape.

(c) Exhaust Systems and Enclosure

Exhaust ventilation and process enclosures shall be used wherever practicable to control workplace concentrations. Spark-proof fans and systems shall be designed and maintained to prevent the accumulation or recirculation of benzene into the workplace. In addition, necessary measures shall be taken to ensure that discharge outdoors will not produce a health hazard to humans, animals, or plants.

(d) General Housekeeping

Emphasis shall be placed upon cleanup, inspection and repair of equipment and leaks, proper storage of materials, and assurance that escape routes are kept clear. Sanitation shall meet the requirements of 29 CFR 1910.141, as amended.

(e) Disposal

(1) All local, state, and federal regulations concerning waste disposal into landfills, streams, municipal treatment plants, or impounding basins shall be followed.

(2) Benzene or benzene-containing materials shall not be discharged where there is a potential for vapor ignition.

(f) Food

Food preparation and eating should be prohibited in benzene work areas.

(g) **Restricted Access to Benzene Areas**

Entry to any area where there is the possibility of exposure to benzene shall be permitted only on the basis of need; all persons entering shall be protected as required for workers regularly assigned to that area.

Section 7 - Monitoring and Reporting Requirements

Workroom areas where it has been determined, on the basis of an industrial hygiene survey or the judgment of a compliance officer, that environmental levels do not exceed one-half the environmental standard shall not be considered to have benzene exposure. Records of these surveys, including the basis for concluding that air levels are not above one-half the environmental standard, shall be maintained until a new survey is conducted. Surveys shall be repeated when any process change indicates a need for reevaluation or at the discretion of the compliance officer. Requirements set forth below apply to areas in which there is benzene exposure.

Employers shall maintain records of accidental benzene release requiring evacuation. In addition, records of environmental exposures to benzene shall be maintained based upon the following sampling and recording schedules except as otherwise indicated by a professional industrial hygiene survey. In all monitoring, samples representative of the exposure in the breathing zone of employees shall be collected. An adequate number of samples shall be collected to permit construction of a time-weighted average (TWA) exposure and ceiling concentration for every operation or process. The minimum number of representative TWA determinations for an operation or process shall be based on the number of workers exposed as

provided in Table I-2 or as otherwise indicated by a professional industrial hygiene survey.

Periodic environmental sampling and biologic sampling shall be timed so that results from both procedures will reflect representative worker exposures to benzene.

(a) Initial and Recurrent Sampling Procedures

(1) The first environmental sampling shall be completed within 6 months of the promulgation of a standard incorporating these recommendations.

(2) Samples shall be collected and analyzed at least quarterly for the evaluation of the work environment and to determine adherence to the recommended standard.

(3) Employees or their representatives shall have the opportunity to observe environmental monitoring.

(b) Special Sampling Procedures

(1) Environmental monitoring of an operation or process shall be repeated at 15-day intervals when the benzene concentrations have been found to exceed the recommended environmental standard. In such cases, suitable control measures shall be instituted, and monitoring shall continue at 15-day intervals until 2 consecutive surveys indicate the adequacy of the controls.

(2) Environmental samples shall be taken within 30 days after installation of a new process or process change.

(c) Recordkeeping Procedures

(1) Records of all sampling and medical examinations shall be maintained for at least 20 years after the individual's employment is

terminated. Records shall indicate the type of personal protection devices, if any, in use at the time of sampling. Records shall be maintained and classified so that each employee shall be able to obtain information on his own environmental exposure.

TABLE I-2
SAMPLING SCHEDULE

<u>Number of Employees Exposed</u>	<u>Minimum Number of TWA Determinations</u>
1-20	50% of the total number of workers
21-100	10 plus 25% of the excess over 20 workers
over 100	30 plus 5% of the excess over 100 workers

II. INTRODUCTION

This report presents the criteria and the recommended standard based thereon which were prepared to meet the need for preventing occupational diseases arising from exposure to benzene. The criteria document fulfills the responsibility of the Secretary of Health, Education, and Welfare, under Section 20(a)(3) of the Occupational Safety and Health Act of 1970 to ". . . develop criteria dealing with toxic materials and harmful physical agents and substances which will describe . . . exposure levels at which no employee will suffer impaired health or functional capacities or diminished life expectancy as a result of his work experience."

The National Institute for Occupational Safety and Health (NIOSH), after a review of data and consultations with others, formalized a system for the development of criteria upon which standards can be established to protect the health of workers from exposure to hazardous chemical and physical agents. It should be pointed out that any recommended criteria for a standard should enable management and labor to develop better engineering controls resulting in more healthful work practices and should not be used as a final goal.

These criteria for a standard for benzene are part of a continuing series of criteria developed by NIOSH. The proposed standard applies only to the processing, manufacture, and use of benzene or its release as an intermediate, byproduct, or impurity therefrom as applicable under the Occupational Safety and Health Act of 1970.

The standard was not designed for the population-at-large, and any extrapolation beyond general occupational exposures is not warranted. It

is intended to (1) protect against injury from benzene, (2) be measurable by techniques that are valid, reproducible, and available to industry and official agencies, and (3) be attainable with existing technology.